LR-4688
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RESEARCH ARTICLE Legume Research- An International Journal, Volume Issue : ()

Effect of Organic and Inorganic Sources of Nutrients on Growth, Yield Attributes and Nutrient Uptake of Soybean in *Vertisols* of Rajasthan

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10.18805/LR-4688

ABSTRACT

Background: Soybean [*Glycie max* (L.) Merril] is a very important oil seed and protein rich crop. It has the specific character to fix atmospheric nitrogen through root nodule bacteria in symbiotic relationship. A field experiment was conducted during *kharif*, 2019 at ARS farm, College of Agriculture, Ummedganj, Kota (Rajasthan). To find out the effect of organic and inorganic sources of nutrients on growth, yield attributes and nutrient uptake of soybean in *Vertisols* of Rajasthan. The soil of the experimental field comes under *Vertisols* with clay loam texture having low to medium fertility status and good porosity.

Methods: The experiment consisted of 10 treatments *viz*. T_0- Control (Absolute), T_1- RDF (20-40-40), T_2- 75% RDF + FYM (2.0 t ha^{-1}), T_3- 50% RDF + FYM (4.0 t ha^{-1}), T_4- 75% RDF + FYM (2.0 t ha^{-1})+*Rhizobium,* T_5- 50% RDF + FYM (4.0 t ha^{-1}) + *Rhizobium*, T_6- 75% RDF + Vermicompost (1.0 t ha^{-1}), T_7- 50% RDF + Vermicompost (2.0 t ha^{-1}), T_8- 75% RDF+Vermicompost (1.0 t ha^{-1}) + *Rhizobium*, T_9- 50% RDF + Vermicompost (2.0 t ha^{-1}) + *Rhizobium.* The experiment was laid out in randomised block design and was replicated thrice.

Result: Among the nutrient management treatment, application of 75% RDF + Vermicompost (1.0 t ha^{-1}) + Rhizobium (T_8) resulted into maximum plant height (58.70 cm), branches plant^{-1} (5.60), chlorophyll content (2.84 mg g^{-1}), total nodules per plant (47.40), effective nodules (31.59) and dry weight (84.20 mg), pods plant^{-1} (41.90), seeds pod^{-1} (3.47), grain yield (1380 kg ha^{-1}), haulm yield (1885 kg ha^{-1}), biological yield (3325 kg ha^{-1}), protein (42.25%) and oil content (19.92%), N, P, K content and their uptake, with maximum gross return (53042.71 Rs ha^{-1}), net return (28980.71 Rs ha^{-1}) and B:C ratio (2.20) in soybean crop.

Key words: FYM, Nodulation, *Rhizobium japonicum*, Soybean, Vermicompost.

INTRODUCTION

Soybean (*Glycine max* L.) belongs to family *Leguminaceae* or *Fabaceae* and Sub- family *Papilionaceae*. It is famous as the 'golden bean' of the 20th century which is also used as food beverage. It is containing 38-42% protein, 20-22% edible oil in the grain and 26% carbohydrates, 4% minerals, 2% phospholipids, rich in poly unsaturated fatty acid, vitamin C, 5-6% crude fibre and lysine amino acid. Soybean being a highly nutrient exhaustive legume requires higher amount of nutrients, particularly phosphorous and potassium for its optimum production. Estimated production of soybean in world is 364.33 million tonnes and area is 127.19 million hectares whereas in India it was 12.10 million tonnes production from an area of 10.80 million hectares and in Rajasthan is 1.16 million tonnes production and area is 0.93 million hectares (Anonymous, 2018).

Consecutive use of organic manures, biofertilizers and inorganic fertilizers to archives sustained crop production and maintain the soil health is the basic need of the hour. INM is the best approach for better utilization of resources and to produce crops with less expenditure. Organic manures are used to supply both macro and micronutrients and sustain amount of humic substances particularly humic and fulvic acid that helps to maintain soil reaction. Organic sources of nutrients are derived from animal, human and agriculture wastes (*e.g.* composting and crop residues). Vermicompost is rich organic manure consist of macro and micronutrients, plant growth promoting substances, beneficial micro-organisms that are necessary for plant growth (Todkari *et al*. 2001). Seed inoculation with effective *Rhizobium* inoculant is recommended to ensure additional nodulation and N_2 fixation for maximum growth and yield of soybean crop. The organic manures along with bio fertilizers help in reducing the dose of inorganic fertilizer, which in turn reduces the cost of cultivation and help in improving the soil health. Therefore, this study was undertaken to analyze the effect of combined use of organic and inorganic sources of nutrients on growth, yield and nutrient uptake of soybean in the *Vertisols* of Rajasthan.

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How to cite this article: Meena, N., Sharma, M.K., Meena, D.S., Choudhary, S., Bhil, K. and Danga, N. (2022). Effect of Organic and Inorganic Sources of Nutrients on Growth, Yield Attributes and Nutrient Uptake of Soybean in *Vertisols* of Rajasthan. Legume Research. DOI: 10.18805/LR-4688.

Submitted: 07-06-2021 **Accepted:** 21-02-2022 **Online:** 04-05-2022

MATERIALS AND METHODS

A field experiment was conducted during *kharif*, 2019 on ARS farm at College of Agriculture, Ummedganj, Kota. The soil of the experimental site was medium black (*Vertisol*s) having clay loam texture, low in available nitrogen (240.50 kg ha^{-1}), medium in available phosphorus (17.40 kg ha^{-1}) and high in available potassium (420.55 kg ha^{-1}) with pH of 7.6, EC (0.36) and medium in organic carbon (0.52%). The experiment consisted of 10 treatments *viz.* T_0- Control (Absolute), T_1- RDF (20-40-40), T_2- 75% RDF + FYM (2.0 t ha^{-1}), T_3- 50% RDF + FYM (4.0 t ha^{-1}), T_4- 75% RDF0+FYM (2.0 t ha^{-1})+*Rhizobium,* T_5- 50% RDF+FYM (4.0 t ha^{-1})+*Rhizobium*, T_6- 75% RDF+Vermicompost (1.0 t ha^{-1}), T_7- 50% RDF+Vermicompost (2.0 t ha^{-1}), T_8- 75% RDF+ Vermicompost (1.0 t ha^{-1})+*Rhizobium*, T_9- 50% RDF+ Vermicompost (2.0 t ha^{-1})+*Rhizobium.* The experiment was laid out in randomised block design and was replicated thrice. Kota is characterized by sub-tropical, semi-arid climate, temperature often exceed 40°C during summer and sometimes touches 45°C, minimum temperature falls below 5°C during winter season. The average rainfall 575 mm, contributed from south-west monsoon during July to September. Soybean crop sown using variety JS-335 with 80 kg ha^{-1} seed rate in *kharif*, 2019.

The number of nodules and dry weight of root nodules were recorded at 50 DAS. The five randomly selected plants are uprooted carefully to avoid unwanted shattering of root nodule from each treatment. The nodules of plant^{-1} counted and then oven dried at constant temperature to record the nodules dry weight with help of electronic weight balance.While observations on plant growth, yield and yield attributing parameters, such as plant height, plant population, numbers of branches per plant, chlorophyll content, pods per plant, seeds per pod, seed index, oil and protein content, grain yield, haulm yield, harvest index was recorded following standard procedures. Total chlorophyll content of leaves determined by the method advocated by Arnon (1949). Protein content in grain was determined by multiplying per cent nitrogen in grain with a constant factor 6.25 (AOAC 1960). Extraction of oil content by soxhlet extraction unit as per method described by AOAC (1960). Nitrogen was estimated in plant by microkjeldahl distillation method (Bremner, 1965), Phosphorus determination by Vanado Molybdo-phosphoric acid yellow colour method of Jackson (1967) and Potassium determination by flame-photometer as described by Jackson, (1973). To find out the most profitable treatment, economics of various treatments was worked out in terms of net returns and benefit: Cost ratio. In order to test the significance of variation in experimental data obtained for various treatment effects, the data were statistically analysed as described by Fisher (1950).

Chlorophyll content (mg g^{-1})

Total chlorophyll content (mg g^{-1}) =

$$\frac{(20.2 \times A_{645}) + (8.03 \times A_{663})}{1000 \times \text{Weight of leaf sample taken (g)}}$$

RESULTS AND DISCUSSION

Growth attributing characters

The data on plant height, plant population and branches produced by plant at different growth stages is presented in Table 1 and depicted in Fig 1. Application of T_8- 75% RDF+ Vermicompost (1.0 t ha^{-1})+*Rhizobium* significantly influent the growth attributing parameters *i.e.*, plant height (58.70 cm), branches plant^{-1} (5.60), chlorophyll content (2.84 mg g^{-1}). The basal application of chemical fertilizers meets the nutritional requirement of crop for proper establishment and growth during the initial period. At subsequent stages vermicompost ensures the proper supply of macro-and micro-nutrients, vitamins and plant growth promoting hormones which have positive effect on plant growth and development. The use of vermicompost would have facilitated better aeration, adequate drainage, improved soil biological activities and created a favourable soil environment for deeper proliferation of roots and higher nutrient extraction from soil, caused more vigorous plant growth. The increased plant height and branches might be due to the involvement of nutrients in cell wall development and cell differentiation which resulted in elongation of shoot and root in plants. Similar results were obtained by Verma *et al.* (2017) who had reported that an appropriate supply of nutrients through organic and inorganic sources increased the growth attributes of soybean. The results are in conformity with the findings of Morya *et al.* (2018), Chauhan *et al.* (2016), Prajapati *et al.* (2016), Armin *et al.* (2016), Jain (2015), Konthoujam *et al.* (2013) and Dwivedi and Kumar (2012).

Number and dry weight of root nodules

A perusal of data (Table 1 and Fig 2) clearly indicated that nutrient management practices considerably influenced the number of nodules. Application of 75% RDF+Vermicompost (1.0 t ha^{-1})+*Rhizobium* (T_8) significantly promoted nodules plant^{-1} at 50 DAS (47.40) as compared to absolute control. The similar trend as in total root nodules per plant, the nutrient management practices considerably influenced the production of effective nodules. Application of 75% RDF+ Vermicompost (1.0 t ha^{-1})+*Rhizobium* (T_8) significantly promoted effective nodules at 50 DAS (31.59) as compared to absolute control. Application of 75% RDF + Vermicompost (1.0 t ha^{-1})+*Rhizobium* (T_8) significantly promoted dry weight of nodules at 50 DAS (84.20) as compared to absolute control. The increase in nodules and their dry weight is the response of inoculation by *Rhizobium japonicum* which might have accelerated the rhizobia activity in the rhizosphere and hence such response. Nodules are the niches of micro organisms and fixed atmospheric nitrogen. This increase ascribed due to better root development and profuse nodulation on account of increase in the rhizobia activity in the rhizosphere due to increased nutrients availability, which resulted in the formation of active and a greater number of root nodules. The results are in close agreement with the findings of Sharma *et al.* (2018) Konthoujam *et al.* (2013),

Verma *et al.* (2017) Singh and Kumar (2012), Dwivedi and Kumar (2012) Mohod *et al.* (2010), Reddy *et al.* (2009), Dhakal *et al.* (2016) and Morya *et al.* (2018).

Yield and yield attributes

The yield and yield attributes are presented in Table 2, Table 3 and Fig 3. Application of T_8- 75% RDF+Vermicompost (1.0 t ha^{-1})+*Rhizobium* significantly influent the yield and yield attributing parameters *i.e.*, pods $plant^{-1}$ (41.90), seeds pod^{-1} (3.47) grain yield (1380 kg ha^{-1}), haulm yield (1885 kg ha^{-1}), biological yield (3325 kg ha^{-1}) over control (T_0). The maximum harvest index was recorded at the treatment T_8 and the value is (41.52%). Benefits accruing from the integrated use of organic with inorganic fertilizers might be attributed to better supply of nutrients along with conducive physical environment leading to better root activity and higher nutrient absorption, which resulted better plant growth and superior yield attributes responsible for high yield (Thakur *et al.*, 2011). Parjapti *et al.* (2016) also reported the improved yield attributes of soybean with integration of synthetic fertilizers and organic manures. Photosynthates are synthesized in chloroplasts containing chlorophyll of which the nitrogen is one of the constituents and thus with the increased level of nitrogen the crop productivity also increases. Earlier Sharma *et al.* (2018) also proved the significance of integrated use of organic and inorganic fertilizers towards improvement in

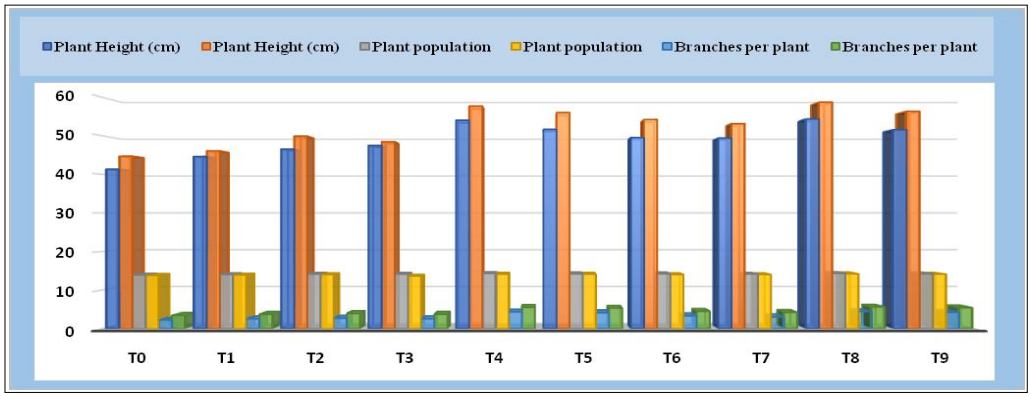

Fig 1: Effect of organic and inorganic sources of nutrients on plant height, plant population, branches $plant^{-1}$ at 50 DAS and at harvest.

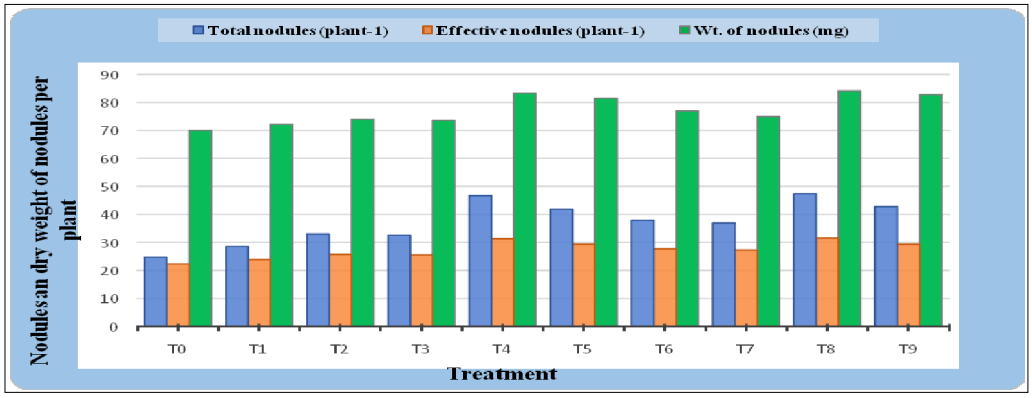

Fig 2: Effect of organic and inorganic sources of nutrients on nodules $plant^{-1}$ at 50 DAS.

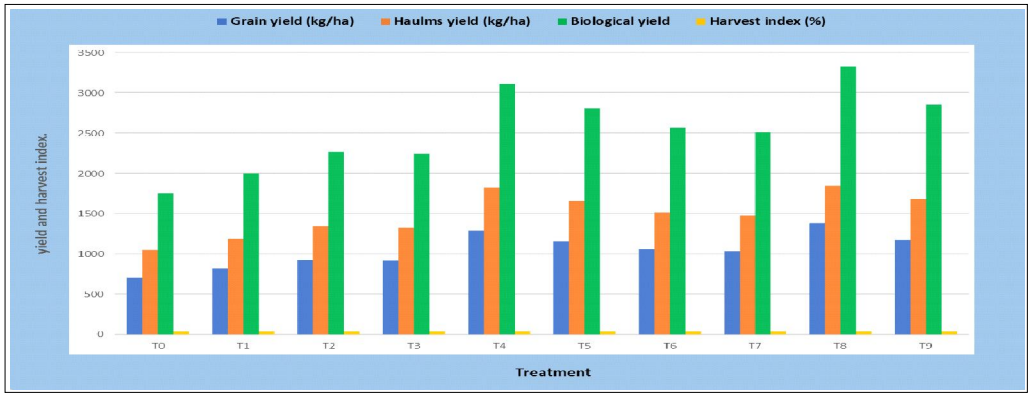

Fig 3: Effect of organic and inorganic sources of nutrients on grain yield haulms yield and harvest index.

Table 1: Effect of Organic and Inorganic sources of Nutrients on plant height, plant population, branches plant^{-1} and nodules plant^{-1} in soybean.

Treatment	Plant height (cm)		Plant population (no. of plants m^{-1} row)		Branches plant^{-1}		Chlorophyll content (mg/g)		Nodules plant^{-1} at 50 DAS	
	50 DAS	At harvest	50 DAS	At harvest	50 DAS	At harvest	50 DAS	Total	Effective	Wt. (mg)
T_0- Control (Absolute)	41.33	44.70	13.90	13.80	2.20	3.40	1.74	24.70	22.24	70.00
T_1- RDF (20-40-40)	44.64	46.10	14.00	13.90	2.50	3.70	1.95	28.60	23.84	72.20
T_2- 75% RDF+FYM (2.0 t ha^{-1})	46.55	49.90	14.10	14.00	2.70	3.90	2.16	33.00	25.67	74.00
T_3- 50% RDF+FYM (4.0 t ha^{-1})	47.51	48.44	14.10	13.60	2.50	3.70	2.13	32.60	25.52	73.60
T_4- 75% RDF+FYM (2.0 t ha^{-1}) + Rhizobium	54.01	57.67	14.30	14.10	4.30	5.50	2.83	46.70	31.32	83.30
T_5- 50% RDF+FYM (4.0 t ha^{-1}) + Rhizobium	51.66	55.98	14.20	14.10	4.10	5.30	2.61	41.90	29.36	81.50
T_6- 75% RDF+ Vermicompost (1.0 t ha^{-1})	49.52	54.22	14.20	14.00	3.30	4.50	2.39	37.90	27.69	77.00
T_7- 50% RDF+Vermicompost (2.0 t ha^{-1})	49.39	53.13	14.10	14.00	3.00	4.20	2.36	36.90	27.29	75.00
T_8- 75% RDF+Vermicompost (1.0 t ha^{-1})+ Rhizobium	54.34	58.70	14.30	14.20	4.40	5.60	2.84	47.40	31.59	84.20
T_9- 50% RDF+Vermicompost (2.0 t ha^{-1})+ Rhizobium	51.56	56.33	14.20	14.10	4.20	5.40	2.65	42.80	29.37	82.80
S.Em. ±	0.82	0.80	0.29	0.29	0.11	0.11	0.06	1.15	0.46	0.65
CD at 0.05%	2.45	2.39	NS	NS	0.32	0.32	0.19	3.42	1.36	1.94

Table 2: Effect of Organic and Inorganic sources of n=utrients on yield attributes, yield and economics of soybean.

Treatment	Pods plant^{-1}	Seed pod^{-1}	Seed index (%)	Grain yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
T_0- Control (Absolute)	31.21	2.50	9.02	703	1046	1749	40.20	27127.02	9755.02	1.34
T_1- RDF (20-40-40)	33.33	2.61	9.85	815	1183	1998	40.80	31419.07	12001.07	1.44
T_2- 75% RDF+FYM (2.0 t ha^{-1})	35.41	2.73	10.22	925	1339	2264	40.87	35656.26	14644.26	1.49
T_3- 50% RDF+FYM (4.0 t ha^{-1})	35.38	2.83	10.19	916	1325	2241	40.87	35308.97	12701.97	1.37
T_4- 75% RDF+FYM (2.0 t ha^{-1})+Rhizobium	41.83	3.37	10.65	1284	1821	3105	41.36	49457.12	28395.12	1.86
T_5- 50% RDF+FYM (4.0 t ha^{-1})+Rhizobium	39.62	2.95	10.57	1152	1654	2806	41.06	44393.06	21736.06	1.62
T_6- 75% RDF+Vermicompost (1.0 t ha^{-1})	37.54	3.04	10.59	1056	1511	2567	41.14	40688.91	16676.91	1.44
T_7- 50% RDF+Vermicompost (2.0 t ha^{-1})	37.48	3.14	10.55	1033	1477	2510	41.16	39801.40	11194.40	1.27
T_8- 75% RDF+Vermicompost (1.0 t ha^{-1})+ Rhizobium	41.90	3.47	10.68	1380	1845	3325	41.52	53042.71	28980.71	2.20
T_9- 50% RDF + Vermicompost (2.0 t ha^{-1})+ Rhizobium	39.74	3.26	10.62	1171	1682	2853	41.04	45126.48	16469.48	1.40
S.Em. ±	0.67	0.02	0.19	28.72	43.75	72.15	0.14	-	-	-
CD at 0.05%	1.99	0.07	NS	85.32	129.98	214.37	NS	-	-	-

the crop yield of soybean. Comparable findings were reported by Mamia *et al.* (2018), Kolpe and Bodake (2017), Verma *et al.* (2017), Dhakal *et al.* (2016), Chauhan *et al.* (2016), Jain (2015), Tyagi *et al.* (2014) and Awasarmal *et al.* (2013).

Quality parameters

The nutrient management practices considerably influenced the protein and oil content in seed of soybean. The protein and oil content in soybean affected by various treatments are presented in Table 3. Application of T_8- 75% RDF+ Vermicompost (1.0 t ha^{-1})+*Rhizobium* significantly enhanced protein content (42.25%) and oil content (19.92%). Because nitrogen is a basic constituent of protein and application of nitrogen either inorganic or organic sources ultimately increased the nitrogen availability which results improved protein content in seed. The results are in conformity with the findings of Konthoujam *et al.* (2013) and Reddy *et al.* (2009). Increase in oil content might be due to the balanced nutrition of the crop. The macro and micro nutrients supplied through chemical fertilizer and organic manures helped in synthesis of fatty acids and their esterification by accelerating biochemical reactions in glyoxylate cycle. The results are in conformity with the findings of Kolpe *et al.* (2017) Verma *et al.* (2017) and Reddy *et al.* (2009).

Nutrient content and uptake

The data presented in Table 3 and Fig 4 revealed that the application of 75% RDF+Vermicompost (1.0 tha^{-1})+ Rhizobium provided highest nitrogen, phosphorous and potassium content in grain and haulm after harvesting the crop which is significantly superior to control and at par with 75% RDF+FYM (2.0 t ha^{-1})+Rhizobium (T_4). The minimum nitrogen content was recorded in absolute control (5.58%). Addition of nutrients to soil through chemical fertilizers and vermicompost significantly enhanced the uptake of different nutrients by grain and haulm in comparison to the control plot. The data presented in Table 4 and Fig 5 revealed that maximum uptake of N, P, K by grain and haulm individually or together was noticed with application of 75% RDF+ Vermicompost (1.0 t ha^{-1})+Rhizobium (T_8) than the remaining treatments, found at par with the application of 75% RDF+

Table 3: Effect of Organic and Inorganic sources of Nutrients on quality parameters and nutrient content in grain and haulm.

Treatment	Protein content (%)	Oil content (%)	Nitrogen (%)		Phosphorous (%)		Potassium (%)	
			Grain	Haulm	Grain	Haulm	Grain	Haulm
T_0- Control (Absolute)	34.88	16.68	5.58	1.13	0.50	0.18	1.21	3.56
T_1- RDF (20-40-40)	36.31	17.32	5.81	1.17	0.52	0.19	1.25	3.64
T_2- 75% RDF+FYM (2.0 t ha^{-1})	37.69	17.92	6.03	1.21	0.54	0.19	1.30	3.72
T_3- 50% RDF+FYM (4.0 t ha^{-1})	37.50	17.84	6.00	1.20	0.54	0.19	1.29	3.70
T_4- 75% RDF+FYM (2.0 t ha^{-1}) + Rhizobium	42.13	19.87	6.74	1.33	0.60	0.22	1.44	3.96
T_5- 50% RDF+FYM (4.0 t ha^{-1}) + Rhizobium	40.69	19.24	6.51	1.30	0.58	0.21	1.39	3.88
T_6- 75% RDF+Vermicompost (1.0 t ha^{-1})	39.19	18.58	6.27	1.25	0.56	0.20	1.34	3.80
T_7- 50% RDF+Vermicompost (2.0 t ha^{-1})	39.00	18.50	6.24	1.25	0.56	0.20	1.34	3.79
T_8- 75% RDF+Vermicompost (1.0 t ha^{-1})+ Rhizobium	42.25	19.92	6.76	1.34	0.60	0.22	1.44	3.96
T_9- 50% RDF+Vermicompost (2.0 t ha^{-1})+ Rhizobium	40.88	19.32	6.54	1.30	0.58	0.21	1.40	3.89
S.Em. ±	0.37	0.17	0.06	0.01	0.005	0.001	0.01	0.02
CD at 0.05%	1.10	0.49	0.18	0.03	0.014	0.004	0.03	0.05

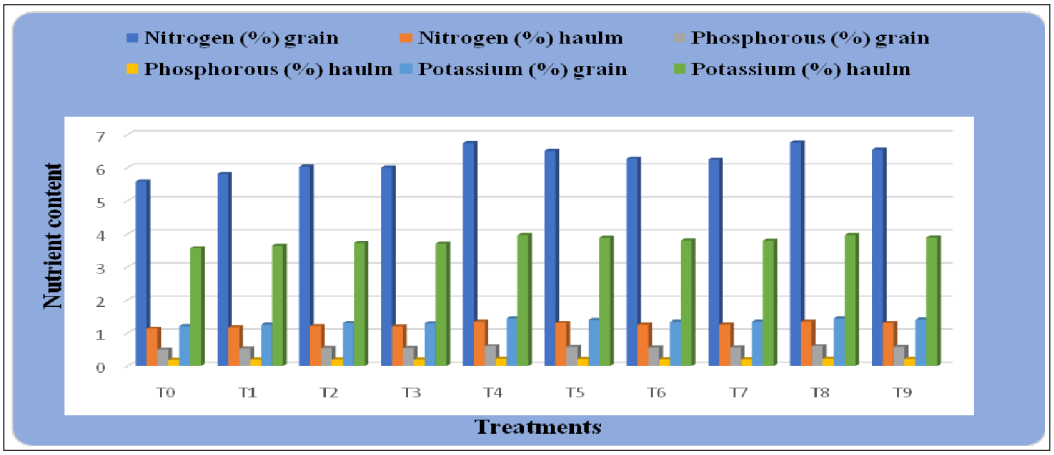

Fig 4: Effect of organic and inorganic sources of nutrients on nutrient content in grain and haulm after harvesting of crop.

Table 4: Effect of Organic and Inorganic sources of Nutrients on nutrient uptake by grain, haulm and total uptake.

Treatment	Nitrogen (kg ha^{-1})			Phosphorous (kg ha^{-1})			Potassium (kg ha^{-1})		
	Uptake by grain	Uptake by haulm	Total uptake	Uptake by grain	Uptake by haulm	Total uptake	Uptake by grain	Uptake by haulm	Total uptake
T_0- Control (Absolute)	39.27	11.79	51.06	3.56	1.94	5.50	8.49	37.28	45.77
T_1- RDF (20-40-40)	47.41	13.84	61.25	4.28	2.28	6.56	10.22	43.04	53.26
T_2- 75% RDF+FYM (2.0 t ha^{-1})	55.80	16.19	71.99	5.02	2.67	7.69	11.99	49.75	61.74
T_3- 50% RDF+FYM (4.0 t ha^{-1})	55.04	15.98	71.02	4.96	2.63	7.59	11.84	49.10	60.93
T_4- 75% RDF+FYM (2.0 t ha^{-1})+Rhizobium	86.66	24.44	111.11	7.74	4.03	11.76	18.48	72.09	90.57
T_5- 50% RDF+FYM (4.0 t ha^{-1})+Rhizobium	75.13	21.48	96.61	6.72	3.54	10.26	16.04	64.21	80.26
T_6- 75% RDF+Vermicompost (1.0 t ha^{-1})	66.21	18.95	85.15	5.94	3.12	9.06	14.19	57.38	71.57
T_7- 50% RDF+Vermicompost (2.0 t ha^{-1})	64.53	18.46	82.99	5.79	3.04	8.83	13.84	55.97	69.80
T_8- 75% RDF+Vermicompost (1.0 t ha^{-1})+ Rhizobium	93.18	24.75	117.93	8.33	4.08	12.41	19.87	73.05	92.92
T_9- 50% RDF+Vermicompost (2.0 t ha^{-1})+ Rhizobium	76.59	21.93	98.52	6.85	3.61	10.47	16.37	65.42	81.78
S.Em. ±	2.16	0.63	2.78	0.19	0.10	0.29	0.44	1.79	2.22
CD at 0.05%	6.41	1.87	8.27	0.57	0.30	0.87	1.30	5.31	6.59

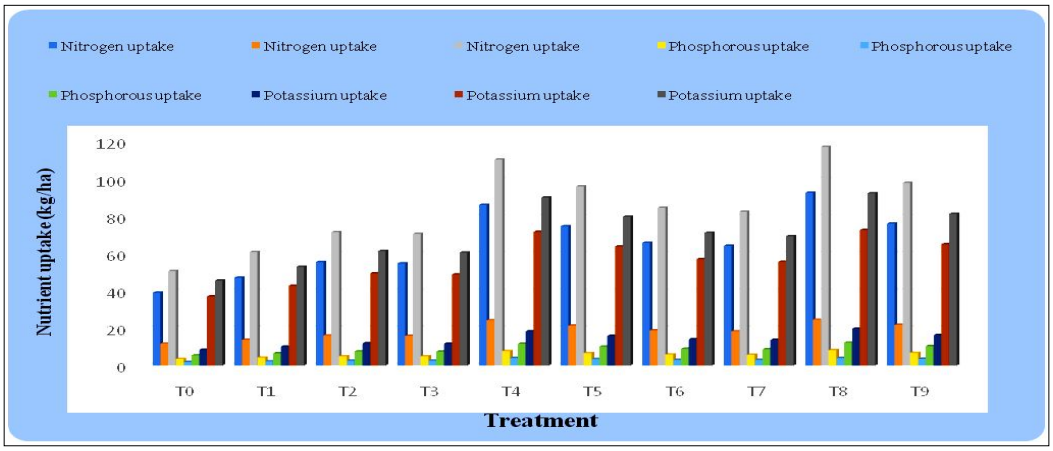

Fig 5: Effect of organic and inorganic sources of nutrients on nutrient uptake by grain, haulm and total uptake.

FYM (2.0 t ha^{-1})+Rhizobium (T_4). The combined application of chemical fertilizers along with enough bulk of vermicompost has always stimulated the uptake of nutrients and partly might be because of stimulated microbes flush and improved root growth due to congenial soil physical condition. The increased nitrogen content and uptake might be due to increased supply of all essential nutrients directly through organic and inorganic sources to crop or indirectly through checking the losses of nutrient from soil solution thereby increase the nutrient use efficiency (Tyagi, 2014). It is expected that with the application of vermicompost there was increase in the availability of phosphorus to plant and because of this, the content of phosphorus in plant also increased. Increment in phosphorus content in plant is also expected due to better buffering capacity of vermicompost for incipient moisture stress and improving phosphorus availability to plant. The results were in conformity with the findings of Dhakal *et al.* (2016), Tyagi (2014) and Konthoujam *et al.* (2013).

Economics

Among nutrient management approaches, the application of T_8- 75% RDF+Vermicompost (1.0 t ha^{-1})+*Rhizobium* had considerably maximum gross return (53042.71 Rs ha^{-1}), net return (28980.71 Rs ha^{-1}) and maximum B:C ratio (2.20) compare to other treatment followed by treatment T_4 - 75% RDF+FYM (2.0 t ha^{-1})+*Rhizobium* (Table 3). The higher net return and B: C ratio was associated with its higher grain and haulm yield per unit of added cost. Kolpe and Bodake (2017), Verma *et al.* (2017) and Konthoujam *et al.* (2013) also found that the economics of organic and inorganic sources of nutrient treatments resulted in significantly higher gross and net returns over control.

CONCLUSION

On the basis of present investigation, it can be concluded that the application of 75% RDF+Vermicompost (1.0 t ha^{-1})+ Rhizobium (T_8) significantly increased the growth, yield, yield

attributing characters and N, P, K content and their uptake, protein and oil content in soybean crop. Application of 75% RDF+Vermicompost (1.0 t ha^{-1})+Rhizobium (T_8) had considerably maximum gross return (53042.71 Rs ha^{-1}), net return (28980.71 Rs ha^{-1}) and maximum B:C ratio (2.20) compared to other treatments. Hence, this combination of integrated nutrient management proved as productive, remunerative and beneficial for soil health in clay loam soils of ARS, Kota.

Conflict of interest: None.

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